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aspen mortality in rocky mountain campgrounds

Abstract

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Aspens die from canker disease infections as a result of mechanical injuries to the live bark inflicted by thoughtless campers. Dead trees usually are cut to reduce camper hazard. Aspen loss is related to campground age. A desirable aspen-type camp unit can be degraded to a treeless site of grass, forbs, and shrubs within 10 to 20 years. The management of aspen campgrounds must be altered if the resource is to be maintained.

Keywords: Recreation use impact, campground degradation, aspen mortality, insects, diseases, *Populus tremuloides.*

About the covers:

Front—A beautiful aspen campsite in Freeman campground, Routt National Forest. Although every tree in the immediate area of the campsite has already been wounded 4 years after campground development, the setting is still natural and attractive.

Back—A once beautiful aspen campsite in the Transfer campground, San Juan National Forest, 14 years after development. All trees in the immediate area of the campsite are dead or have been cut because of disease. The area is no longer attractive to campers.

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Aspen Mortality in Rocky Mountain Campgrounds

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T. E. Hinds

The goal of recreation management is to optimize user satisfaction consistent with certain administrative, budgetary, and resource constraints. To do this, the manager needs to understand the impacts of recreation upon the resource. He must know the character of change to be expected with certain levels and types of use, and how the predicted changes in the physical environment will affect management (Lime and Stankey 1971).

Numerous recreation sites have been developed in aspen stands in the western part of the United States because of their attractiveness and closeness to scenic wonders. General observations by Barker,[2] Hester,[3] and Hinds and Krebill (1975) during the past few years have indicated that aspens in campgrounds have an abnormal incidence of diseases. Accelerated mortality often has resulted in a pronounced reduction in the overall quality of the recreation site (fig. 1). While the cause of aspen decline has never been studied thoroughly, it frequently has been attributed to man-induced trampling, as well as to such natural compounding conditions as poor site, stand age, rotten trees, insects, and successional transition to conifers. Past research has not sufficiently emphasized the response of campground trees to recreation use.

The bark of western aspen[4] is smooth, soft, and living. Because of the fragile nature of its bark, the tree is extremely susceptible to damage, and trunk wounds are quite common (Hinds 1964, Hinds and Krebill 1975). Wounds not only cause physical damage to tree function, but they also are the most common entrance points of canker disease organisms, the most serious cause of tree mortality. Krebill (1972) found that mechanical injury to the trunks of aspen in the Gros Ventre elk winter range in northwestern Wyoming, caused by elk and moose, predisposed the aspen stands to increased disease and accelerated mortality. Aspen stands in campgrounds

[2]Barker, P. A. 1972. Maintaining and enhancing environmental and aesthetic qualities of intensively used recreation sites, a problem analysis. Research Work Unit FS-INT-1902. (On file at the Intermountain Forest and Range Experiment Station, Logan, Utah.)

[3]Memorandum from D. A. Hester, Chief, Branch of Pest Control, to E. J. Grambo, Assistant Regional Forester, August 31, 1966. (On file (No. 5230) at Rocky Mountain Region, Denver, Colorado.)

[4]Common and scientific names of diseases, insects, plants, and vertebrates mentioned are found at the end of this Paper.

Figure 1.—The lower portion of Maroon Lake campground in July 1973 shows the lack of tree screening between campsites due to dead and down trees. Average camp unit tree loss in this campground has been 68 percent in 12 years.

likewise are subjected to trunk injury, frequently from the knives, hatchets, and axes that recreationists often carry.

The objective of this study, therefore, was to assess aspen mortality in Colorado campgrounds in relation to trunk injury and the incidence of diseases and insects.

Profile of the Campgrounds Studied

Approximately 350 of the 4,880 public family campgrounds in National Forests are in Colorado. Of these Colorado campgrounds, at least 85 (over 17 percent) are in areas where more than 33 percent of the overstory trees are aspen. Many of the campgrounds were established in the mid-1960's as a result of "Operation Outdoors," a Forest Service program to expand recreational facilities in the National Forests. Most of the campgrounds sampled in this study were established at that time. Some campgrounds developed prior to 1960 also were relocated or rehabilitated as part of that program. Rehabilitation consisted of closing old camp units and establishing new ones in unused portions of an expanded campground. In this analysis, the rehabilitation date was used as the year developed.

The 17 campgrounds examined in this study contain 422 camp units, and are rustic rather than modern. Each camp unit has a table and fireplace fixed in place. Water and sanitation facilities are provided for the campground in general. Most campgrounds sampled are some distance from major highways (fig. 2), insuring that camping—rather than overnight lodging—is the primary use. The physical and recreational data for the 16 Colorado and 1 New Mexico campgrounds used for this study are given in table 1.

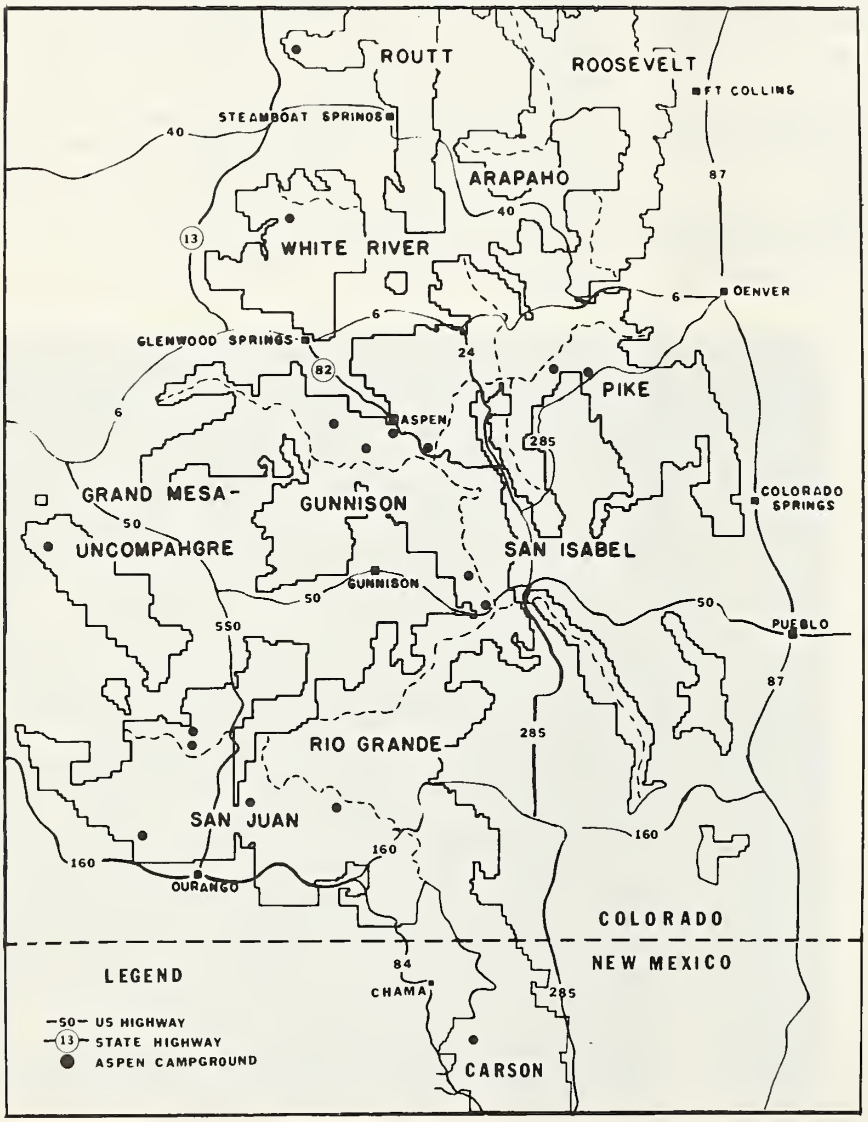


Figure 2.—General locations of aspen campgrounds sampled in Colorado and New Mexico in relation to the major highways.

Table 1.--Physical and recreational data on aspen campgrounds sampled in this study

National Forest and campground	Year devel-oped	Acres	Eleva-tion	Site tree age	Site class	Camp units	Sample plots: Inter-ior	Sample plots: Perim-eter	Sample plots: Inter-unit	People at one time[1]	Days in season	Visitor days 1972	Theo-retical capacity[2]
		No.	*Feet*	*Years*		*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*Percent*
GRAND MESA-UNCOMPAHGRE NF:													
Divide Fork	1965	6	9,200	93	70	7	2	2	2	45	78	3,400	48
Matterhorn	1966	6	9,500	80	60	23	2	2	2	130	78	22,700	112
Sunshine	1965	8	9,500	107	60	10	2	2	2	60	78	10,900	116
GUNNISON NF:													
Agate	1957	33	9,000	113	50	34	3	3	3	170	93	6,100	19
Snowblind	1965	26	9,800	62	70	23	2	2	2	115	93	8,700	41
PIKE NF:													
Michigan Creek	1964	9	10,000	89	50	13	3	3	3	65	102	4,900	37
Kenosha	1965	16	10,000	87	40	25	3	3	2	125	214	8,000	15
ROUTT NF:													
Freeman	1969	14	8,800	110	40	12	2	2	2	60	86	2,000	19
SAN JUAN NF:													
Cimarrona	1959	12	8,400	99	60	17	3	3	2	85	153	9,600	37
Transfer	1959	7	8,500	80	50	13	2	2	2	65	154	3,100	15
Transfer Park	1954	17	8,600	81	60	25	3	3	3	125	124	6,300	17
WHITE RIVER NF:													
Difficult	1964	11	8,000	84	70	47	5	5	5	259	137	37,200	57
Maroon Lake	1961	47	9,600	91	70	62	7	7	7	340	137	90,600	107
North Fork	1966	55	8,000	71	30	46	4	4	2	235	163	2,800	4
Redstone	1952	24	7,200	66	40	24	3	3	3	120	184	11,700	26
Weller	1964	3	9,200	85	70	11	2	1	1	55	137	7,700	51
CARSON NF:													
Canjilon Lakes	1962	15	9,800	125	50	40	5	5	2	200	100	16,700	42

[1]Number of people a campground is designed to sustain at one time.

[2]A use index, which is the ratio expressed in percent of actual campground occupancy in relation to total number of people the campground is designed to sustain during its open season (1972 basis).

Certain socioeconomic ramifications are associated with these aspen campgrounds. A monetary value of $2 per visitor day has been assigned as the social benefit derived from camping (U.S. Water Resources Council 1973). If we accept this estimate of value, the social benefits derived from Colorado campgrounds in the aspen type alone amount to over $1.5 million per year. The social benefit values of campgrounds in this study amounted to over $500,000 in 1972, or an average of $1,500 per acre. This value is somewhat greater than the $1,200 per acre of development that Barker[2] derived for the public recreation sites on the National Forests in the Intermountain West. The social benefit value of a campground like Maroon Lake campground, for example, with its 90,600 visitor days amounted to $181,200; $3,855 on a per-acre basis; or $2,876 per camp unit in 1972.

Most campgrounds in this study were maintained under the campground fee system used in 1973. Due to site deterioration, fees were not charged at three of the campgrounds and their future closure was anticipated. The camping area of two others was confined. A timber sale to remove 50 cords of firewood was in progress in one; the other was partially closed for lack of funds for proper maintenance, that is, dead tree removal. At today's replacement cost of $4,500 per camp unit, it would cost nearly $2 million to replace the campgrounds examined in this study.

Providing recreationists with sustained satisfaction as well as protecting the investment and the natural environment in these aspen campgrounds should be of considerable importance.

Study Methods

Only campgrounds in which aspen was the predominant type (overstory more than 66 percent aspen) were studied. Campgrounds were selected so that they would be distributed throughout Colorado, and could be sampled in 1 year (1973). The sample also included one campground in northern New Mexico. Although campgrounds often contained

both family camp units and family picnic units, only the camp units were sampled. Beginning with the first unit in a campground, every fifth or tenth unit was examined until a minimum of 10 percent of the camp units were sampled. Three types of temporary plots were established:

1. **An Interior Plot,** used to determine the condition of the trees within a camp unit, consisted of a 0.05-acre circular plot (26-foot 4-inch radius) with the center located midway between the fire pit and the picnic table. All trees over 3.0 inches in diameter at breast height (d.b.h.) were described. The number and apparent cause for dead or down trees, and the diameter of stumps were recorded. Saplings 1.0 to 2.9 inches d.b.h. were counted.

2. **A Perimeter Plot,** to determine the condition of trees surrounding the immediate camp unit, was established to supplement the interior plot. The perimeter plot size was variable; that is, size was determined by the height of the tallest tree on the perimeter of the campsite which conceivably could fall into the campsite area. The perimeter plot radius, determined by adding the height of the tallest tree to the radius of the interior plot, was measured from the same center point used for the interior plot. Only overstory tree data describing the live, dead, or cut trees over 5 inches d.b.h., insect attack, cankers, or other diseases were taken. Saplings were not counted.

3. **An Inter-Unit Plot,** to determine the condition of trees which provide a screening effect between camp units, was established midway between the interior plot and an adjacent camp unit. Plot size and information recorded were the same as for the interior plot.

Campground information was obtained from Forest Service RIM sources (Recreation Information Management System, James 1971). Dominant tree height and ages were taken to determine site class of the campground in general. Jones' (1966) aspen site index was used for site comparisons. Tree vigor was rated as normal or poor. Thin crowns, small leaves, and poor growth typified poor vigor.

Bark injury associated with wood-boring insects was noted. A number of species of beetles, mainly roundheaded borers (Cerambycidae) and flatheaded borers (Buprestidae), are known to cause bark injury. Common borers from the Rocky Mountains include the poplar borer, the poplar butt borer, and the bronze birch borer. No attempt was made to distinguish which borer was involved or the frequency of infestation on the trees examined. The presence of these insects was noted only on the basis of external evidence.

Results

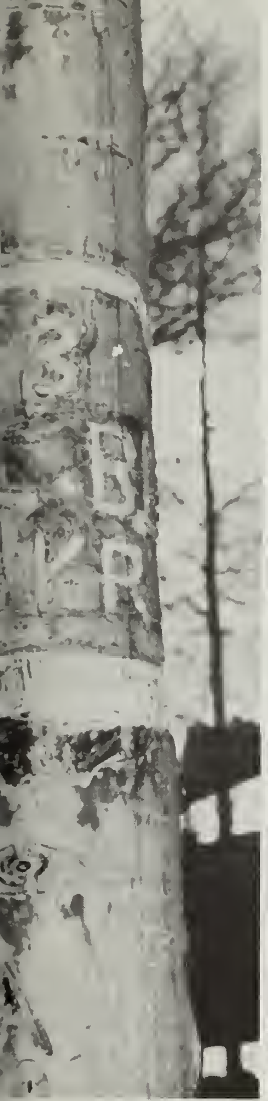
Within the 17 campgrounds, there were 422 camp units. A total of 53 interior, 52 perimeter, and 45 inter-unit temporary plots were established at camp units. The average campground age was 11 years; the interior plots averaged 12 live trees and 6 dead trees and/or stumps. The number of live trees and associated damage, and tree loss and cause in the individual campgrounds are summarized in table 2 (see details in the appendix).

Table 2.--Live aspen and aspen losses found in the campground plots, and percentages of common anomalies associated with them

Common anomalies	Interior plots No.	Interior plots %	Perimeter plots No.	Perimeter plots %	Inter-unit plots No.	Inter-unit plots %
LIVE TREES:	636		3,571		666	
With mechanical injuries		83		--		19
With canker infections:		47		5		14
Ceratocystis		29		2		8
Cytospora		10		1		4
Cenangium		5		1		1
Cryptosphaeria		2		1		1
Hypoxylon		1		<1		<1
Trunk over half girdled by canker infections		22		2		6
Phellinus tremulae[1] conks		6		1		5
Wood borer infestation		18		<1		5
TREE LOSS:	331		1,303		283	
Cut or down		28		21		19
Dead standing		6		6		11
with cankers--		98		94		93
Cytospora		50		42		57
Cenangium		35		47		30
Cryptosphaeria		8		4		4
Ceratocystis		5		1		2
Hypoxylon		0		1		1

[1] *P. tremulae* = *Fomes igniarius* var. *populinus* (Neu.) Campb.

Mechanical injuries to the trunks were found on at least half of the aspens in all interior plots, on at least 75 percent of the trees in 12 of the 17 campgrounds, and on all of the trees in 4 campgrounds. Single and multiple injuries, all apparently done since campground construction, extended from groundline up to 10 feet on the trunk (fig. 3). Although injuries were found on all sides of the tree trunks, a high proportion of them were on the side facing the plot center. All are potential entry points for insects, canker, and other disease organisms which could be fatal to the host tree.



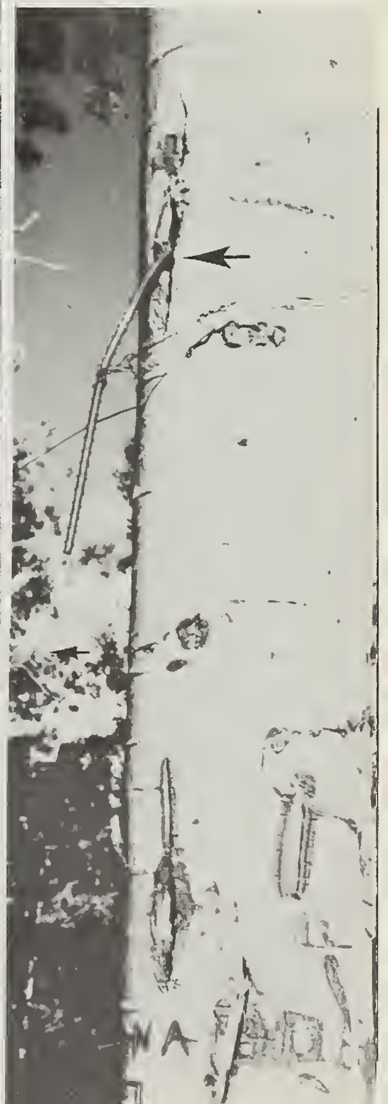


Figure 3.—Mechanical injuries like these on the aspen trees in the campgrounds studied were frequent, continuous, and malicious. The trunk wounds are prime entrance points for canker diseases; symptoms of the prevalent ones are shown in figures 4-8.

Cankers were more common on live trees in the interior plots than in the other plots. Of the interior-plot trees, Ceratocystis canker (fig. 4) was found on 29 percent; Cytospora (fig. 5) on 10 percent; Cenangium (fig. 6) on 5 percent; Cryptosphaeria (fig. 7) on 2 percent; and Hypoxylon (fig. 8) on 1 percent.

Although 66 percent of the original stems over 3.0 inches in diameter on the interior plots are still living, one-third are infected with canker diseases that already have girdled more than half of the trunk circumference. Only time will tell how long these infected trees will survive, but surely no longer than 10 years.

Conks of the false tinder fungus, *Phellinus tremulae* (fig. 9), indicating extensive heart rot (Hinds 1963), were found in camp units of 15 of the 17 campgrounds. Fruiting bodies of other decay fungi were found on less than 1 percent of the trees. The artist's conk, *Ganoderma applanatum,* scaly Pholiota, *Pholiota squarrosa,* and the honey mushroom, *Armillariella mellea,* were the ones encountered. As is typical of these root and butt rot fungi, the fruiting bodies were found at the base of the trees. Such diseased trees are subject to windthrow at any time.

The incidence of borer attack on interior-plot aspens was 3½ times greater than on the inter-unit plots, and 18 times greater than on the perimeter plots, which had the least tree mortality.

Dead trees are cut in campgrounds as standard procedure for hazard control. Some are cut by campers for firewood. Stumps of these cut trees, which remain intact for several years, are a graphic record of aspen loss and subsequent degradation of the campsite (fig. 10). Of the 34 percent tree loss on the interior plots, 28 percent had been cut, while 6 percent were dead and still standing. Assuming that all standing dead or otherwise hazardous trees were removed for camper safety during campground development, the average rate of tree loss in the interior plots has been 3.6 $\pm$ 1.0 percent per year (fig. 11) and 2.8 $\pm$ 0.7 percent per year for all plots combined (95 percent confidence level) since campground construction.

Other factors such as sunscald, snow damage, insects, and wind contribute to aspen loss; however, canker-caused mortality appears to be the greatest factor. About 95 percent of the dead standing aspens in the three plot areas were killed by cankers (see table 2).

Stand age of the campgrounds varied from 62 to 125 years. Interior-plot tree loss decreased with stand age from 44 percent in the 60- to 80-year age class to 30 percent in stands over 100 years old.

Over half of the campgrounds studied were on good to fair sites; that is, site class 60 or better. Interior-plot tree loss amounted to 33 percent on site class 70, 39 percent on site class 60, 50 percent on site class 50, 43 percent on site class 40, and 20 percent on site class 30.

Half of all trees rated as having poor vigor were suppressed. Vigor was poor for 29 percent of the trees on the interior plots in contrast to 17 percent on the inter-unit plots. On the interior plots, 80 percent of the poor-vigor trees had trunk wounds, 56 percent were cankered, and 21 percent were infested with borers.

Aspen saplings were found on 57 percent of the interior plots, but averaged only four per plot. Saplings were found on 61 percent of the inter-unit plots, and averaged 11 per plot. Other tree species larger than 5.0 inches d.b.h. constituted only 3.8 percent of the total number of trees observed, and were omitted from the analysis.

Discussion

In view of the aspen losses found in this study, managers of recreation sites must recognize that recreationists increase aspen mortality. The devastating role of insects and diseases will increase as trees in these public campgrounds grow older. Aspen mortality observed in this study was due largely to diseases and, to a much lesser degree, borer infestations—but these were secondary causes. The primary cause was mechanical injury to the trunks which, by damaging the bark, predisposed the trees to invasion by virulent plant pathogens.

Mechanical injury can be characterized as deliberate cuts in the bark apparently inflicted with knives, hatchets, and axes. Such vandalism was of a magnitude to be considered of epidemic seriousness. Unless this vandalism is curtailed, a principal value that attracts recreationists to these campgrounds, namely the tree cover, will disappear due to the user's own maliciousness, negligence, and/or ignorance (fig. 12).

Although tree mortality in western aspen campgrounds has been attributed to several causes, the problem has had very little comprehensive study. A study by Beardsley and Wagar (1971) of the Sunrise campground in northern Utah reported that mortality and windthrow did not seem to increase among trees on their study plots following the first 4 years after construction. I observed the Sunrise campground in 1974, 10 years after construction, and found aspen deterioration similar to that in Colorado and New Mexico. At 3 aspen camp units in the campground, 95 percent of the 65 live trees had mechanical injuries, 68 percent had cankers, 32 percent were more than half girdled by the cankers, 25 percent had borer damage, 1 tree was dead, and 30 had been cut since campground construction. The incidence of Cenangium canker appeared to be increasing rapidly throughout the campground (see fig. 6).

Figure 4.—Ceratocystis cankers initiated at 12-year-old injury, presumably ax inflicted. Many Ceratocystis-infected trunk wounds do not exhibit this typical target-shaped canker.

Figure 5.—Cytospora canker approximately 4 years old continues to spread on this weakened stem.

Figure 6.—Cenangium canker has girdled 5 of these trees within 6 years at Sunrise Campground in northern Utah, a campground observed as an auxiliary to the campgrounds of the study.

Figure 7.—Cryptosphaeria cankers on 12-inch aspen estimated to be 5 or 6 years old. They appear to have been initiated as camper-caused trunk wounds.

Figure 8.—Aspen two-thirds girdled by Hypoxylon canker in approximately 8 years.

Figure 9.—Hooflike conks of *Phellinus* emanating from old branch stubs. Although infection can occur at trunk wounds, conks usually indicate extensive heart rot that originated many years ago.

Figure 10.—Tree stumps are visible in early June at Transfer campground. They remain hidden by tall grasses and leafy shrubs during the summer months as seen in figure 18 (top).

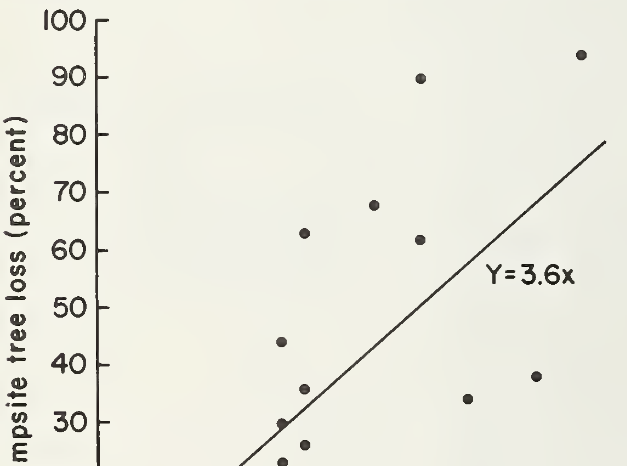


Figure 11.—Relationship between average tree loss in the interior plots and campground age, based on 53 camp units in 17 aspen campgrounds.

Figure 12.—Sunshine campground, Colorado, Unit 1, with no live trees on campsite. Average diameter of four stumps on the site was 16.6 inches, comparable to the trees in the background. The perimeter plot (90-ft 4-inch radius) had 66 large living trees, 20 cut, and 1 dead standing. Dining tarps for shade will be common on such sites in the future. Average campsite tree loss in this campground is 44 percent in 8 years.

Trampling, poor site, stand age, rotten trees, insects, and the natural successional transition to conifers may all contribute to tree mortality. The most important and fundamental factor, however, seems to be trunk wounding by the campground user. Aspen sites usually support a luxuriant understory of grasses, shrubs, and forbs (Paulsen 1969). Although quantitative information concerning the undergrowth was not taken, casual observations during this study indicate that growth of grasses and shrubs increased when trees were removed (see figs. 15-19). These observations tend to support findings by Beardsley and Wagar (1971) that the effects of trampling on ground-cover vegetation is not as serious in the aspen as in the coniferous types.

There is a rule of thumb among resource managers that 20 to 40 percent of theoretical capacity is the optimum campground usage. In this study, nine campgrounds had less than 40 percent usage in 1972. Tree loss on interior plots averaged 48 percent in 12 years. The remaining eight campgrounds had an average usage of 72 percent and interior-plot tree loss of 30 percent in 9 years. Campground use in the early days of the older campgrounds is unknown. Usage, however, was probably great enough that considerable tree wounding occurred and subsequent tree mortality was high over the years.

While there may be a relationship between site class and tree mortality, no definite conclusions can be drawn from this study due to the numerous site classes involved and the small number of samples examined for each site class. Healthy vigorous aspen stands over 100 years old are not uncommon in the West. While high tree mortality is normal in younger stands due to overcrowding, other factors made mortality abnormally higher in campgrounds. Small trees with thin bark usually had more trunk wounds penetrating into the cambium layer than larger, older trees with their thicker bark. This difference in bark thickness, ease of bark wounding, and subsequent infection of trunk injuries predisposes younger trees to a faster rate of mortality than the older ones.

Rot in Colorado aspen stands under 100 years old usually is not serious; decay may amount to 4 to 13 percent of the gross cubic foot volume (Davidson et al. 1959). The major trunk rot is caused by *Phellinus tremulae. Ganoderma applanatum* causes a butt and root rot which predisposes a tree to windthrow. Both fungi are widespread. In a study of natural stands in western Colorado, Hinds (1964) found that 6 percent of the trees had *P. tremulae* and 0.2 percent had *G. applanatum* conks. In the present study, 6 percent of the trees in the interior plots had *P. tremulae* conks and 0.3 percent had *G. applanatum*—essentially no difference between the two studies. Because decay progresses fairly slowly, most of the aspens showing signs of decay were no doubt infected when the campgrounds were constructed, and decay to date is probably no greater than that found in natural stands.

Insects and diseases may defoliate aspen stands. They usually are not persistent enough over the years to cause tree mortality, however. Persistent wood borer infestations, on the other hand, are common. Aspen decline and mortality caused by borers has not been studied in western aspen. Evidence of trunk damage by a single agrilus larva (fig. 13) indicates that numerous attacks would cause substantial cambium damage. After repeated heavy attacks by the poplar borer, brood trees (fig. 14) remain alive, but the large, oval-shaped tunnels in the trunk make the tree susceptible to wind breakage and serve as openings for the introduction of various rots and canker fungi. Borer infestations tend to vary directly with stem diameter and inversely with density of stocking (Ewan 1960). In this study, the removal of trees at camp units reduced the stand density, which may have promoted an increase in borer infestation. The role that wood borers play in campground tree mortality remains unknown.

As very few other tree species were found on the camp units, it appears that a natural successional transition to conifers is not taking place.

The following comparison of the incidence of stand and tree characteristics found on the interior plots and 4,075 trees examined in 31 natural stands (Hinds 1964) indicates the damage trends in the camp units.

	Natural stands	**Interior plots**
	(*Percent*)	
Stand basis:		
Live trees	91	66
Standing dead trees	9	6
Cut or down trees	(no record)	28
Live-tree basis:		
With trunk wounds	2	83
With trunk cankers:	11	47
Ceratocystis	4	29
Cytospora	4	10
Cenangium	2	5
Cryptosphaeria	(no record)	2
Hypoxylon	<1	1
With borer damage	3	18

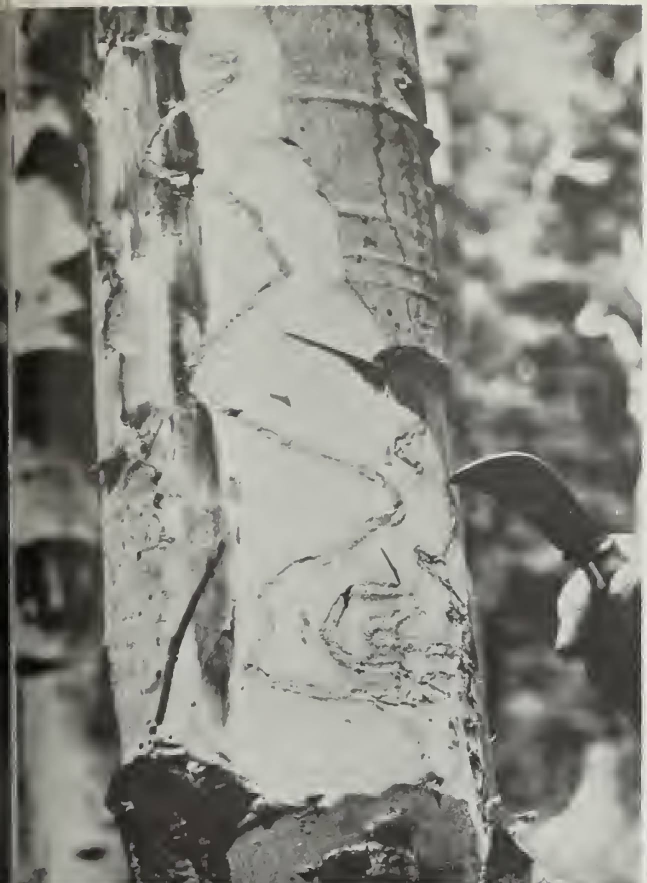


Figure 13.—Bark stripped off a portion of an aspen trunk reveals zigzag tunnels between the phloem and wood that mark an infestation of a single aspen agrilus larva.

Figure 14.—External evidence of borer damage on aspen: rough, black, bark spots over the location of healed egg niches, and sap flow from exit holes.

An aspen site begins to deteriorate the day a road opens up the area. Tree removal during road building causes trunk wounds, not only on the lower portion of the boles but also in the treetops. The stand canopy is opened and trees along the new road soon begin to suffer from sunscald, wood borers, and wound-infecting fungi. Campsite construction follows a similar pattern. Tree removal during site preparation causes further canopy opening and additional trunk wounds.

Trees on the campsite soon become weakened by thoughtless campers carving on the smooth aspen bark (fig. 15). These wounds become infected, and trees often die within 5 to 10 years. As the trees die and are removed, the stand becomes more open (fig. 16) creating ideal conditions for insect borers and more sunscald (fig. 17). Overall tree vigor declines, mortality increases, and the site is nearly barren of aspen in 10 to 15 years (fig. 18). The reproduction has disappeared—used up for tent pegs, and weiner, marshmallow, and kabob sticks.

Tree wounding and eventual mortality spread outward from the immediate perimeter of the camp unit, until even the trees once used for screening purposes between sites are lost (see figs. 1, 18). Shrubs and forbs multiply because of the reduced competition from overstory vegetation, and lack of trampling by campers who find treeless campsites objectionable. Overall campground deterioration is completed in 25 to 30 years (fig. 19). Campsite recreation cannot be considered as a nonconsumptive use, and the optimum campground usage in aspen campgrounds may well be zero for the sake of the aspen.

Figure 15.—Freeman campground, Unit 6 interior plot, with 16 live trees: all are wounded, 10 cankered, and 7 over half girdled. Present tree loss is two cut and one dead standing (girdled by Cenangium canker). Perimeter plot (71-ft 4-inch radius) has 84 live trees plus 6 cankered, dead standing, and 1 cut. Average camp unit tree loss in this campground is 10 percent in 4 years.

Figure 16.—Kenosha campground, Unit 2 interior plot, with 17 live trees: 14 are wounded, 13 cankered, and 9 over half girdled. Present tree loss is 6 cut and 2 down. Perimeter plot has 32 live trees, 7 cut, 1 down, and 1 dead standing. Average camp unit tree loss in this campground is 23 percent in 8 years.

Figure 17.—Maroon Lake campground. Unit 15 interior plot, with 7 live trees; 10 had been cut. The perimeter plot (68-ft 4-inch radius) has 6 live trees, with 26 cut. Trees on both plots ranged up to 19 inches in diameter at breast height. Average camp unit tree loss in this campground is 68 percent in 12 years.

Figure 18.—Transfer campground. **Top:** View through central portion of campground in August in its final stages of deterioration, with complete lack of tree screening between campsites. Average campsite tree loss in this campground is 90 percent in 14 years. **Bottom:** Unit 4 interior plot with 2 live trees over half girdled by cankers, 11 cut, and 5 dead standing. Perimeter plot (80-ft 4-inch radius) has 16 live trees, 1 cankered, 73 cut, and 22 dead standing.

Figure 19.—Redstone campground. Unit 1 with 2 live trees: 1 wounded, 1 cankered and over half girdled. Average basal diameter of 22 cut trees in the interior plot was 5.3 inches. There were 23 live, 28 cut, and 5 cankered, dead standing trees on the perimeter plot (62-ft 4-inch radius). Average campsite tree loss in this campground is 94 percent in 21 years. Understory vegetation is now oak, aspen, and juniper.

Management Implications

The future of these aspen campgrounds is bleak. Many will have to be closed because of esthetic loss or lack of funds for proper maintenance. The eventual closure of some no doubt will go unnoticed, but closure of others, such as Maroon Lake, will be met by stern public criticism. The management of most, because of their recreation value, must be altered in some manner if the aspen resource is to be maintained. Some of the implications for management which can be concluded from this study are:

- Because campsite degradation as a result of tree loss is caused directly by recreationists, campgrounds should be constructed in a more durable forest-type than aspen if maintenance of a tree cover is important.

- Because of the frequency of mechanical injury to aspen trunks in campgrounds by recreationists, and because this damage is the main precursor to early tree mortality, interpretive signs need to be displayed in aspen campgrounds showing users why they should not injure tree trunks. Coupled with this, a forceful campaign to apprehend and prosecute violators should be instigated.

- Because mortality of the trees already injured will continue at an accelerated pace (there is presently no known way of arresting the progress of the canker diseases), dead tree removal will also have to be accelerated to maintain camper safety.

- Because of the anticipated fate of these aspen campgrounds, remedial possibilities include: (a)

acceptance of unnatural or deteriorated conditions; (b) closure; (c) relocation as deterioration advances; (d) transplanting large conifers from offsite; and (e) site conversion on a long-range basis to other species less susceptible to visitor-caused injury. The foregoing biotic alternatives still need considerable research, however.

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Appendix

Table 3.--The proportion of living trees and associated damage in aspen campground plots in relation to campground age[1]

Campground	Age (years)	Living			Living trees that were: Injured[2]		With cankers			More than one-half girdled			With wood borers		
		Interior	Perimeter	Inter-unit	Interior	Inter-unit	Interior	Perimeter	Inter-unit	Interior	Perimeter	Inter-unit	Interior	Perimeter	Inter-unit
		Percent													
Freeman	4	90	93	85	97	22	53	8	4	27	2	0	18	0	0
Matterhorn	7	88	93	96	72	4	33	1	1	8	0	1	0	0	0
Snowblind	8	94	82	87	94	4	71	0	0	29	0	0	24	0	0
North Fork	8	80	83	79	64	4	64	40	67	26	5	33	11	6	7
Kenosha	8	77	79	67	88	44	57	8	14	27	5	5	39	0	0
Divide Fork	8	70	77	94	100	27	38	0	19	19	0	0	38	0	0
Sunshine	8	56	81	78	100	34	40	5	20	20	2	10	10	0	3
Weller	9	74	74	92	84	23	51	1	3	49	1	0	0	0	0
Difficult	9	64	71	75	75	3	39	0	11	12	0	5	23	0	5
Michigan Creek	9	37	54	72	93	45	100	40	18	79	26	14	7	0	2
Canjilon Lakes	11	87	91	93	93	4	33	1	2	10	1	0	14	0	0
Maroon Lake	12	32	60	49	58	6	39	5	18	19	3	5	3	1	9
Cimarrona	14	38	57	43	100	33	80	3	33	60	0	1	20	3	33
Transfer	14	10	13	11	100	75	100	17	50	0	17	25	50	13	25
Agate	16	66	68	70	63	7	44	1	11	27	1	3	27	0	2
Transfer Park	19	62	81	64	94	97	64	1	47	24	1	13	48	0	45
Redstone	21	6	34	49	50	13	50	3	8	50	3	4	50	0	3
Average	11	66	73	70	83	19	47	5	14	22	2	6	18	<1	5

[1]Basis: 967 stems in 53 interior plots, 4,875 stems in 52 perimeter plots, and 949 stems in the 45 inter-unit plots.
[2]No data recorded on perimeter plots.

Table 4.--The proportion of tree loss and probable cause in aspen campground plots in relation to campground age[1]

Campground	Age (years)	Tree loss			Dead trees that were: Cut or windthrown			Standing dead			With canker[2]		
		Interior	Perimeter	Inter-unit	Interior	Perimeter	Inter-unit	Interior	Perimeter	Inter-unit	Interior	Perimeter	Inter-unit
		Percent											
Freeman	4	10	7	5	75	25	63	25	75	37	100	100	100
Matterhorn	7	12	7	6	100	78	50	0	22	50	0	75	100
Snowblind	8	6	18	13	100	80	75	0	20	25	0	100	100
North Fork	8	20	17	21	27	36	0	73	64	100	100	100	100
Kenosha	8	23	21	33	60	65	43	40	35	57	100	100	83
Divide Fork	8	30	23	6	86	100	0	14	0	100	100	0	100
Sunshine	8	44	19	22	87	96	100	13	4	0	100	100	0
Weller	9	26	26	8	94	100	33	6	0	66	100	0	100
Difficult	9	36	29	25	97	75	54	3	25	46	100	100	100
Michigan Creek	9	63	46	28	59	50	42	42	41	50	100	100	100
Canjilon Lakes	11	13	11	7	56	90	66	44	10	33	81	100	100
Maroon Lake	12	68	40	50	96	80	67	4	20	33	100	74	87
Cimarrona	14	62	43	57	94	94	100	6	6	0	100	100	0
Transfer	14	90	87	89	72	84	94	28	16	6	100	100	100
Agate	16	34	32	20	80	70	38	20	30	62	100	100	100
Transfer Park	19	38	19	36	90	85	80	10	15	20	100	100	50
Redstone	21	94	66	51	97	85	84	3	14	16	100	100	100
Average	11	34	27	30	28	21	19	6	6	11	98	94	93

[1]Basis: Total loss of 331 trees in 53 interior plots, 1,303 in 52 perimeter plots, and 283 in the 45 inter-unit plots.
[2]Tree death was attributed to a canker disease if a standing dead tree was girdled by a canker.

Common and Scientific Names of Diseases, Insects, Plants, and Vertebrates Mentioned

Diseases	
Artist's conk	*Ganoderma applanatum* (Pers. ex Wallr.) Pat.
Cenangium canker	*Cenangium singulare* (Rehm.) Davidson & Cash
Ceratocystis canker	*Ceratocystis fimbriata* Ell. & Halst.
Cryptosphaeria canker	*Cryptosphaeria populina* (Pers.) Sacc.
Cytospora canker	*Cytospora chrysosperma* Pers. ex Fr.
False tinder fungus	*Phellinus tremulae* (Bond.) Bond. et Boris
Honey mushroom	*Armillariella mellea* (Vahl. ex Fr.) Karst.
Hypoxylon canker	*Hypoxylon mammatum* (Wahl.) Mill.
Scaly Pholiota	*Pholiota squarrosa* (Fr.) Kumm.
Insects	
Bronze birch borer	*Agrilus anxius* (Gory)
Poplar borer	*Saperda calcarata* Say
Poplar butt borer	*Xylotrechus obliteratus* (LeC.)
Plants	
Aspen	*Populus tremuloides* Michx.
Juniper	*Juniperus* spp.
Oak	*Quercus gambellii* Nut.
Vertebrates	
Elk	*Cervus canadensis nelsoni* Bailey
Moose	*Alces alces shirasi* Nelson

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1976. Aspen mortality in Rocky Mountain campgrounds. USDA For. Serv. Res. Pap. RM-164, 20 p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

Aspens die from canker disease infections as a result of mechanical injuries to the live bark inflicted by thoughtless campers. Dead trees usually are cut to reduce camper hazard. Aspen loss is related to campground age. A desirable aspen-type camp unit can be degraded to a treeless site of grass, forbs, and shrubs within 10 to 20 years. The management of aspen campgrounds must be altered if the resource is to be maintained.

Keywords: Recreation use impact, campground degradation, aspen mortality, insects, diseases, *Populus tremuloides.*

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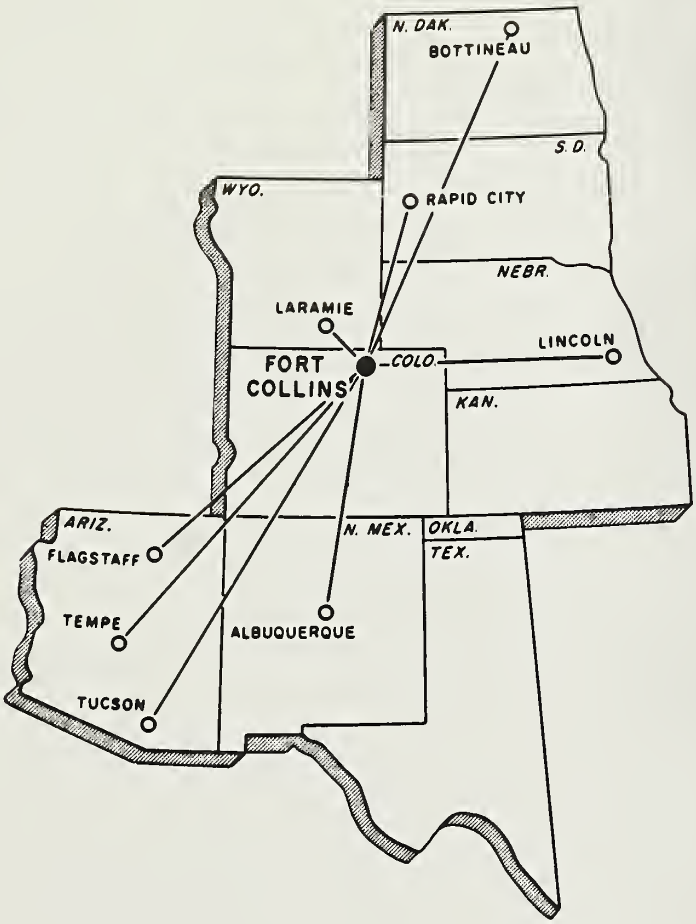
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